NEW Water
*The brand of the Green Bay Metropolitan Sewerage District*

June 23, 2020

Ms. Tania Taff
Department of Natural Resources
2984 Shawano Avenue
Green Bay, WI 54313-6727

RE: Stack Test Results for Fluid Bed Incinerator- Particulate Matter
FID 405004600

Dear Ms. Taff:

Enclosed are results of an emission test conducted on the fluid bed incinerator (FBI) operated at the Green Bay Metropolitan Sewerage District (GBMSD) wastewater treatment plant located in Green Bay, Wisconsin. GBMSD contracted with Environmental Technology & Engineering Inc. to conduct a stack test to demonstrate whether its facility is in compliance with the applicable emission limit for particulate matter (PM) on May 27, 2020. GBMSD is required by the facility Title V Operation Permit, Permit No. 405004600-P30, to conduct a stack test demonstrating compliance with all applicable emission limits within 13 months of the previous compliance test, which was conducted on May 1 and 2, 2019 (the Stack Test Compliance Confirmation).

The results of this recent stack test show emissions of 4.07 milligrams per dry standard cubic meter at 7 percent oxygen, which is in compliance with the limit of 9.6 mg/dscm at 7 percent oxygen. During this testing, the operational parameters of the pollution control equipment operated with the FBI were measured and recorded. These operational parameters will be used to establish allowable operating parameters to follow until the next compliance emission test.

On March 18 and 19, 2020, GBMSD performed compliance emissions testing for the FBI (the March Stack Test). The results showed compliance with all pollutants except for PM. The PM result was unexpected for several reasons and GBMSD does not consider the PM result from the March 2020 testing to be representative of emissions from the FBI. GBMSD has taken several steps to understand the PM result from the March 2020 testing, as described in the May 18, 2020 transmittal to the Department of Natural Resources.

The PM test results included herein, along with the results of the March Stack Test previously submitted, are submitted in accordance with the Stack Test Compliance Confirmation requirement of the permit. We understand the next Stack Test Compliance Confirmation is due by June 27, 2021 which is 13 months after the May 27 stack testing date.

Please feel free to contact me with any questions or concerns you may have about GBMSD's emissions testing.

Green Bay Metropolitan Sewerage District
2231 North Quincy Street | Green Bay, WI 54302 | Phone (920) 432-4893 | Fax (920) 432-4302 | www.newwater.us

Sincerely,

**GREEN BAY METROPOLITAN SEWERAGE DISTRICT**

Julie C. Maas

Julie Maas
Environmental Compliance Specialist

Appendices

1) TESTING TO DEMONSTRATE COMPLIANCE WITH FILTERABLE PARTICULATE AIR EMISSIONS LIMITS on the FLUID BED INCINERATOR EXHAUST (I08, S08, C08) May 27, 2020

cc: Ms. Louise Gross, US EPA
Mr. Dan Schaufelberger, US EPA
Mr. James Bonar Bridges, Wisconsin DNR
Mr. Michael Huenink, ETE

Report to

**GREEN BAY METROPOLITAN SEWERAGE DISTRICT**
**(FID 405004600)**
**Green Bay, Wisconsin**

for

# TESTING TO DEMONSTRATE COMPLIANCE WITH FILTERABLE PARTICULATE AIR EMISSIONS LIMITS

**on the**

**FLUID BED INCINERATOR EXHAUST (I08, S08, C08)**

**May 27, 2020**

ETE

Report to

**GREEN BAY METROPOLITAN SEWERAGE DISTRICT**
**(FID 405004600)**
**Green Bay, Wisconsin**

for

# TESTING TO DEMONSTRATE COMPLIANCE WITH FILTERABLE PARTICULATE AIR EMISSIONS LIMITS

**on the**

**FLUID BED INCINERATOR EXHAUST (I08, S08, C08)**

**May 27, 2020**


Michael J. Huenink
Industrial Hygienist
June 2, 2020

ENVIRONMENTAL TECHNOLOGY & ENGINEERING CORP
13000 W. Bluemound Road Elm Grove, Wisconsin 53122
Phone: (262) 784-2434 Fax: (262) 784 -2436

## EXECUTIVE SUMMARY

On May 27, 2020, Environmental Technology & Engineering Corp (ETE) personnel visited the Green Bay Metropolitan Sewerage District (GBMSD) wastewater treatment facility located in Green Bay, Wisconsin. The purpose of the visit was to perform particulate matter (PM) air emissions testing on the exhaust stack for the Fluid Bed Incinerator (I08, S08, C08) operations and its emissions control system. The operations are required to meet the EPA Standards of Performance for New Stationary Sources: Sewage Sludge Incineration Units [40 CFR 60, Subpart LLLL] and the EPA Standards of Performance for Sewage Treatment Plants [40 CFR 60 Subpart O]. The emission limits are included in Wisconsin Department of Natural Resources (WDNR) Air Pollution Control Construction Permit No. 14-JJW-051-R1.

**The results of the test efforts indicated that the particulate emissions levels were below (in compliance with) both the EPA's Sewage Sludge Incineration emission limit and the WDNR permit limit.** The test results can be summarized as follows:

| Test Parameter | Test | Average Measured PM Emission Concentration (1) | PM Emissions Relative to Process Throughput |
|---|---|---|---|
| | | | |
| Particulate Matter | 1 | 4.03 mg/dscm @ 7% $O_2$ | 0.0528 lb PM/ton dry sludge input |
| | 2 | 4.50 mg/dscm @ 7% $O_2$ | 0.0567 lb PM/ton dry sludge input |
| | 3 | 3.69 mg/dscm @ 7% $O_2$ | 0.0452 lb PM/ton dry sludge input |
| | **AVG** | **4.07 mg/dscm @ 7% $O_2$** | **0.0516 lb PM/ton dry sludge input** |
| | | | |
| **PM Emissions Limits -** | | **9.6 mg/dscm @ 7% $O_2$** | **1.30 lb PM/ton dry sludge input** |
| | | | |

**Notes:** **(1)** These test results are expressed in units corrected to 7% oxygen per EPA Standard
**mg/dscm @ 7% $O_2$** means milligrams per dry standard cubic meter, corrected to 7% $O_2$
**lb PM/ton dry sludge input** means pounds of PM emissions per ton of dry sludge input

## 1.0 GENERAL

On May 27, 2020, Environmental Technology & Engineering Corp (ETE) personnel visited the Green Bay Metropolitan Sewerage District (GBMSD) wastewater treatment facility located in Green Bay, Wisconsin. The purpose of the visit was to perform particulate matter (PM) air emissions testing on the exhaust stack for the Fluid Bed Incinerator (I08, S08, C08) operations and its emissions control system. The operations are required to meet the EPA Standards of Performance for New Stationary Sources: Sewage Sludge Incineration Units [40 CFR 60, Subpart LLLL] and the EPA Standards of Performance for Sewage Treatment Plants [40 CFR 60 Subpart O]. The emission limits are included in Wisconsin Department of Natural Resources (WDNR) Air Pollution Control Construction Permit No. 14-JJW-051-R1.

GBMSD owns and operates a 49 MGD activated sludge wastewater treatment plant. A fluid bed incinerator (I08) processes sewage sludge that has been anaerobically digested, conditioned with polymer, dewatered with centrifuges, and dried in an industrial dryer. Emissions from I08 are controlled by a wet scrubber, wet ESP, and carbon bed (C08A, B, C). Following the emissions controls, exhaust gas is vented to atmosphere through stack S08. Testing was performed on S08 following all emissions control devices. During the testing, GBMSD staff monitored and recorded operational parameters on each of the emission control devices.

The testing was performed under normal process conditions; every attempt was made to run the incinerator operations at 85 percent (or greater) of capacity. GBMSD personnel monitored the fluid bed incinerator operating conditions throughout the test efforts. The documentation of those sludge processing rates is included in Appendix A of this report. The processing levels can be summarized as follows:

| Test | Test Period | Wet Material Processing Rate | Rate of Dry tons of Sludge Produced per Hour |
|---|---|---|---|
| | | | |
| 1 | 08:50 - 09:52 | 10241 lbs/hr | 1.961 tons/hr |
| 2 | 10:06 - 11:08 | 10262 lbs/hr | 2.027 tons/hr |
| 3 | 11:20 - 12:22 | 9998 lbs/hr | 1.985 tons/hr |

Ms. Julie Maas and Mr. Bruce Bartel of GBMSD facilitated in the coordination of the production activities and field test efforts. Ms. Tania Taff of the WDNR - WCR/NOR Air Management (Green Bay), Mr. Quin Kovar of the WDNR - WCR/NOR Air Management (Wausau), and Mr. Andy Seeber of the WDNR - Bureau of Air Management were notified of the test efforts. The field test and analytical efforts (unless noted) were performed by ETE personnel; Michael Huenink was the test team leader.

## 2.0 RESULTS

Testing to determine particulate matter (PM) emissions on the stack was performed isokinetically using EPA Method 5. This test method measured filterable PM emissions; the testing and analysis did not include condensable PM fraction (EPA Method 202 analysis). A brief description of the method is included in Section 3.0 of this report. A sketch showing the sampling ports and point locations on the final discharge stack is included as Figure 2-1.

Three separate 60 minute tests were performed on the stack; the sample volumes were all greater than the minimum required (per the EPA's SSI Standard) volume of 1 dry standard cubic meter of exhaust (35.31 cubic feet). The stack flow parameters measured during testing and the weights of the particulate collected were used to determine the emissions for each test. The detailed total particulate emission results are included as Tables 2-1 through 2-3.

The EPA emission guidelines are all expressed in units of concentration (e.g., parts per million), corrected to 7 percent oxygen levels. The basic equation to "correct" the results would be as follows:

$$\text{Corrected Conc.} = \text{Measured Conc.} \times \frac{(20.9 - 7)}{(20.9 - \%\ O_2)}$$

The results of the test efforts indicated that the particulate emissions levels were below (in compliance with) both the EPA's Sewage Sludge Incineration emission limit and the WDNR permit limit. The test results can be summarized as follows:

| Test Parameter | Test | Average Measured PM Emission Concentration (1) | PM Emissions Relative to Process Throughput |
|---|---|---|---|
| | | | |
| Particulate Matter | 1 | 4.03 mg/dscm @ 7% $O_2$ | 0.0528 lb PM/ton dry sludge input |
| | 2 | 4.50 mg/dscm @ 7% $O_2$ | 0.0567 lb PM/ton dry sludge input |
| | 3 | 3.69 mg/dscm @ 7% $O_2$ | 0.0452 lb PM/ton dry sludge input |
| | **AVG** | **4.07 mg/dscm @ 7% $O_2$** | **0.0516 lb PM/ton dry sludge input** |
| | | | |
| **PM Emissions Limits -** | | **9.6 mg/dscm @ 7% $O_2$** | **1.30 lb PM/ton dry sludge input** |
| | | | |

**Notes: (1)** These test results are expressed in units corrected to 7% oxygen per EPA Standard
**mg/dscm @ 7% $O_2$** means milligrams per dry standard cubic meter, corrected to 7% $O_2$
**lb PM/ton dry sludge input** means pounds of PM emissions per ton of dry sludge input

## INCINERATOR I08 - TEST LOCATION & POINTS
## GBMSD - GREEN BAY, WI

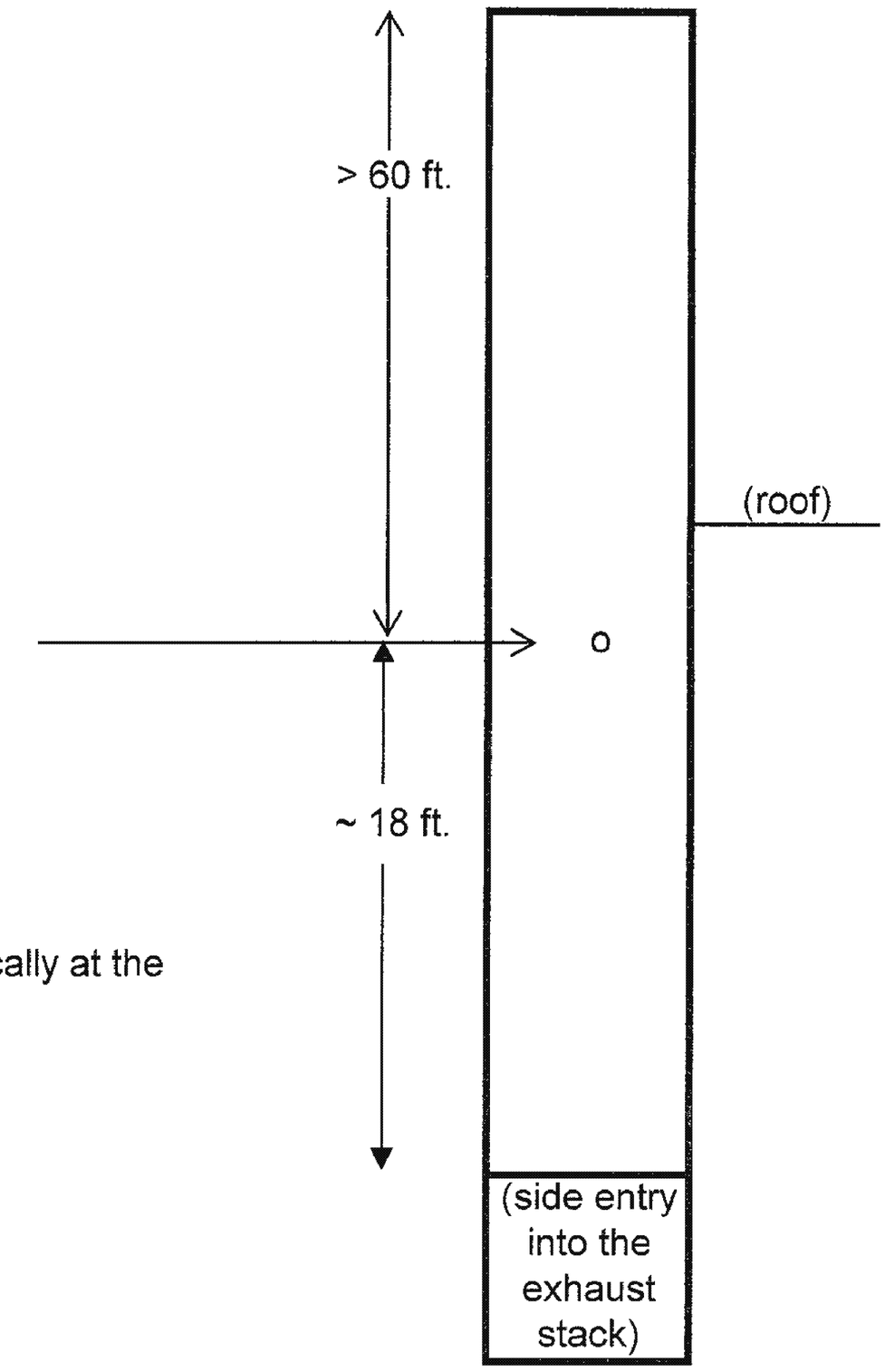
**FIGURE 2-1**

### VELOCITY POINT LOCATIONS

| Point | Distance (in.) from back wall |
|---|---|
| 1 | 1.1 |
| 2 | 3.5 |
| 3 | 7.1 |
| 4 | 16.9 |
| 5 | 20.5 |
| 6 | 22.9 |

**Stack Diameter:** 24 in. (stack runs vertically at the test location)

### SAMPLE PORT LOCATION




**Notes:** 12 PM sampling points used on this round stack;
6 points along each of two perpendicular traverses.
All other gas sampling performed at a single point in the center third of the duct.

**GBMSD - NEW WATER** **I08 STACK** **5/27/20** **TABLE 2-1**

| | | |
|---|---|---|
| **TEST NO.** | 1 | |
| **BAROMETRIC PRESSURE** | 29.28 | IN HG |
| **TIP DIAMETER** | 0.250 | IN |
| **STACK DIAMETER** | 24 | IN |
| **STACK AREA** | 3.142 | FT3 |
| **SAMPLING TIME PER POINT** | 5 | MIN |
| **NUMBER OF POINTS** | 12 | |
| **METER VOLUME** | 55.83 | FT3 |
| **PITOT COEFFICIENT** | 0.84 | |
| **METER COEFFICIENT** | 0.997 | |
| **PARTICULATE COLLECTED** | 0.0050 | GRAMS |
| **WATER COLLECTED** | 29 | ML |
| **STATIC PRESSURE** | -0.54 | IN H2O |

**ORSAT RESULTS**

| **CO2** | **O2** | **CO** | **N2** |
|---|---|---|---|
| 8.30% | 9.80% | 0.00% | 81.90% |

| **POINT** | **STACK TEMP** DEG F | **DELTA P** IN H2O | **ORIFICE DEL P** IN H2O | **METER TEMP** DEG F | **VELOCITY** AFPS |
|---|---|---|---|---|---|
| 1 | 123 | 0.81 | 1.70 | 81 | 53.19 |
| 2 | 124 | 0.85 | 1.79 | 82 | 54.54 |
| 3 | 124 | 0.82 | 1.72 | 84 | 53.56 |
| 4 | 122 | 0.75 | 1.58 | 88 | 51.14 |
| 5 | 121 | 0.92 | 1.93 | 91 | 56.59 |
| 6 | 121 | 0.87 | 1.83 | 95 | 55.03 |
| 7 | 121 | 0.60 | 1.26 | 99 | 45.70 |
| 8 | 121 | 0.76 | 1.60 | 103 | 51.44 |
| 9 | 122 | 0.84 | 1.76 | 108 | 54.12 |
| 10 | 121 | 0.93 | 1.95 | 111 | 56.90 |
| 11 | 121 | 0.97 | 2.04 | 114 | 58.11 |
| 12 | 120 | 0.87 | 1.83 | 118 | 54.98 |
| **AVERAGE** | 122 | | 1.75 | 98 | 53.78 |

| | | | | |
|---|---|---|---|---|
| **DRY STANDARD VOLUME** | 54.89 | SCF | | |
| **PERCENT WATER VAPOR** | 2.43 | % VOL | | |
| **FLOW RATE** | 10136 | ACFM | | |
| | 8773 | DSCFM | | |
| | 14907 | M3/HR | | |
| **PARTICULATE CONCENTRATION** | 0.0014 | GR/DSCF | 3.22 | mg/dscm |
| **PARTICULATE EMISSION RATE** | 0.104 | LB/HR | **4.03** | **mg/dscm @ 7% O2** |
| **LB PART PER 1000 LB GAS** | 0.0025 | | | |
| **ISOKINETIC PERCENT** | 96.1 | | | |
| **DRY SLUDGE FEED RATE** | 1.961 | TONS/HR | | |
| **PM EMISSION FACTOR** | **0.0528** | **LB FILT PM/TON DRY SLUDGE INPUT** | | |

**GBMSD - NEW WATER** **I08 STACK** **5/27/20** **TABLE 2-2**

| | | |
|---|---|---|
| **TEST NO.** | 2 | |
| **BAROMETRIC PRESSURE** | 29.27 | IN HG |
| **TIP DIAMETER** | 0.250 | IN |
| **STACK DIAMETER** | 24 | IN |
| **STACK AREA** | 3.142 | FT3 |
| **SAMPLING TIME PER POINT** | 5 | MIN |
| **NUMBER OF POINTS** | 12 | |
| **METER VOLUME** | 54.75 | FT3 |
| **PITOT COEFFICIENT** | 0.84 | |
| **METER COEFFICIENT** | 0.997 | |
| **PARTICULATE COLLECTED** | 0.0055 | GRAMS |
| **WATER COLLECTED** | 32 | ML |
| **STATIC PRESSURE** | -0.49 | IN H2O |

**ORSAT RESULTS**

| **CO2** | **O2** | **CO** | **N2** |
|---|---|---|---|
| 8.20% | 9.80% | 0.00% | 82.00% |

| **POINT** | **STACK TEMP** DEG F | **DELTA P** IN H2O | **ORIFICE DEL P** IN H2O | **METER TEMP** DEG F | **VELOCITY** AFPS |
|---|---|---|---|---|---|
| 1 | 122 | 0.89 | 1.87 | 118 | 55.76 |
| 2 | 122 | 0.86 | 1.81 | 119 | 54.81 |
| 3 | 122 | 0.79 | 1.66 | 120 | 52.54 |
| 4 | 123 | 0.70 | 1.47 | 121 | 49.49 |
| 5 | 122 | 0.78 | 1.64 | 122 | 52.20 |
| 6 | 122 | 0.98 | 2.06 | 124 | 58.51 |
| 7 | 122 | 0.77 | 1.62 | 127 | 51.87 |
| 8 | 123 | 0.80 | 1.68 | 128 | 52.91 |
| 9 | 123 | 0.82 | 1.72 | 129 | 53.57 |
| 10 | 122 | 0.97 | 2.04 | 130 | 58.21 |
| 11 | 123 | 0.91 | 1.91 | 131 | 56.43 |
| 12 | 123 | 0.73 | 1.53 | 133 | 50.54 |
| **AVERAGE** | 122 | | 1.75 | 125 | 53.91 |

| | | | | |
|---|---|---|---|---|
| **DRY STANDARD VOLUME** | 53.99 | SCF | | |
| **PERCENT WATER VAPOR** | 2.71 | % VOL | | |
| **FLOW RATE** | 10161 | ACFM | | |
| | 8756 | DSCFM | | |
| | 14878 | M3/HR | | |
| **PARTICULATE CONCENTRATION** | 0.00157 | GR/DSCF | 3.60 | mg/dscm |
| **PARTICULATE EMISSION RATE** | 0.115 | LB/HR | **4.50** | **mg/dscm @ 7% O2** |
| **LB PART PER 1000 LB GAS** | 0.0028 | | | |
| **ISOKINETIC PERCENT** | 94.7 | | | |
| **DRY SLUDGE FEED RATE** | 2.027 | TONS | | |
| **PM EMISSION FACTOR** | **0.0567** | **LB FILT PM/TON DRY SLUDGE INPUT** | | |

| GBMSD - NEW WATER | I08 STACK | 5/27/20 | TABLE 2-3 |
|---|---|---|---|

| | | |
|---|---|---|
| **TEST NO.** | 3 | |
| **BAROMETRIC PRESSURE** | 29.26 | IN HG |
| **TIP DIAMETER** | 0.250 | IN |
| **STACK DIAMETER** | 24 | IN |
| **STACK AREA** | 3.142 | FT3 |
| **SAMPLING TIME PER POINT** | 5 | MIN |
| **NUMBER OF POINTS** | 12 | |
| **METER VOLUME** | 54.64 | FT3 |
| **PITOT COEFFICIENT** | 0.84 | |
| **METER COEFFICIENT** | 0.997 | |
| **PARTICULATE COLLECTED** | 0.0043 | GRAMS |
| **WATER COLLECTED** | 35 | ML |
| **STATIC PRESSURE** | -0.54 | IN H2O |

**ORSAT RESULTS**

| **CO2** | **O2** | **CO** | **N2** |
|---|---|---|---|
| 7.90% | 10.30% | 0.00% | 81.80% |

| **POINT** | **STACK TEMP** DEG F | **DELTA P** IN H2O | **ORIFICE DEL P** IN H2O | **METER TEMP** DEG F | **VELOCITY** AFPS |
|---|---|---|---|---|---|
| 1 | 123 | 0.83 | 1.74 | 130 | 53.96 |
| 2 | 123 | 0.77 | 1.62 | 129 | 51.97 |
| 3 | 122 | 0.72 | 1.51 | 130 | 50.21 |
| 4 | 122 | 0.86 | 1.81 | 131 | 54.88 |
| 5 | 122 | 0.99 | 2.08 | 132 | 58.88 |
| 6 | 122 | 0.92 | 1.93 | 132 | 56.76 |
| 7 | 122 | 0.65 | 1.37 | 133 | 47.71 |
| 8 | 122 | 0.74 | 1.55 | 134 | 50.91 |
| 9 | 122 | 0.84 | 1.76 | 136 | 54.24 |
| 10 | 123 | 0.93 | 1.95 | 137 | 57.12 |
| 11 | 122 | 0.97 | 2.04 | 138 | 58.28 |
| 12 | 123 | 0.79 | 1.66 | 139 | 52.64 |
| **AVERAGE** | 122 | | 1.75 | 133 | 53.96 |

| | | | | |
|---|---|---|---|---|
| **DRY STANDARD VOLUME** | 53.92 | SCF | | |
| **PERCENT WATER VAPOR** | 2.96 | % VOL | | |
| **FLOW RATE** | 10172 | ACFM | | |
| | 8740 | DSCFM | | |
| | 14851 | M3/HR | | |
| **PARTICULATE CONCENTRATION** | 0.00123 | GR/DSCF | 2.82 | mg/dscm |
| **PARTICULATE EMISSION RATE** | 0.090 | LB/HR | **3.69** | **mg/dscm @ 7% O2** |
| **LB PART PER 1000 LB GAS** | 0.0022 | | | |
| **ISOKINETIC PERCENT** | 94.8 | | | |
| **DRY SLUDGE FEED RATE** | 1.985 | TONS | | |
| **PM EMISSION FACTOR** | **0.0452** | **LB FILT PM/TON DRY SLUDGE INPUT** | | |

## 3.0 TEST METHODS

The equipment used to sample for particulate matter was the Western Precipitation Division of the Joy Manufacturing Company Emission Parameter Analyzer. Samples were collected and analyzed in accordance with procedures outlined in EPA Method 5 - "Determination of Particulate Emissions from Stationary Sources" as found in 40 CFR Part 60, Appendix A.

The "front half" of the sampling train consisted of a stainless steel probe tip, a heated stainless steel lined probe, and a heated glass fiber filter (or "filterable particulate" filter). Following the front half, the "back half" of the sampling train consisted of a set of several Greenburg-Smith impingers. A schematic drawing of the sampling train is included. The first and second impingers each contained 100 milliliters of de-ionized water, the third impinger was left dry (for any moisture spillover), and the fourth impinger contained a tared amount of silica gel. The gas then passed through a vacuum pump, calibrated dry gas meter, and a calibrated orifice. The temperatures of the stack gas stream, as well as strategic locations within the sampling devices, were monitored by RTDs and read directly from a gauge on the control unit.

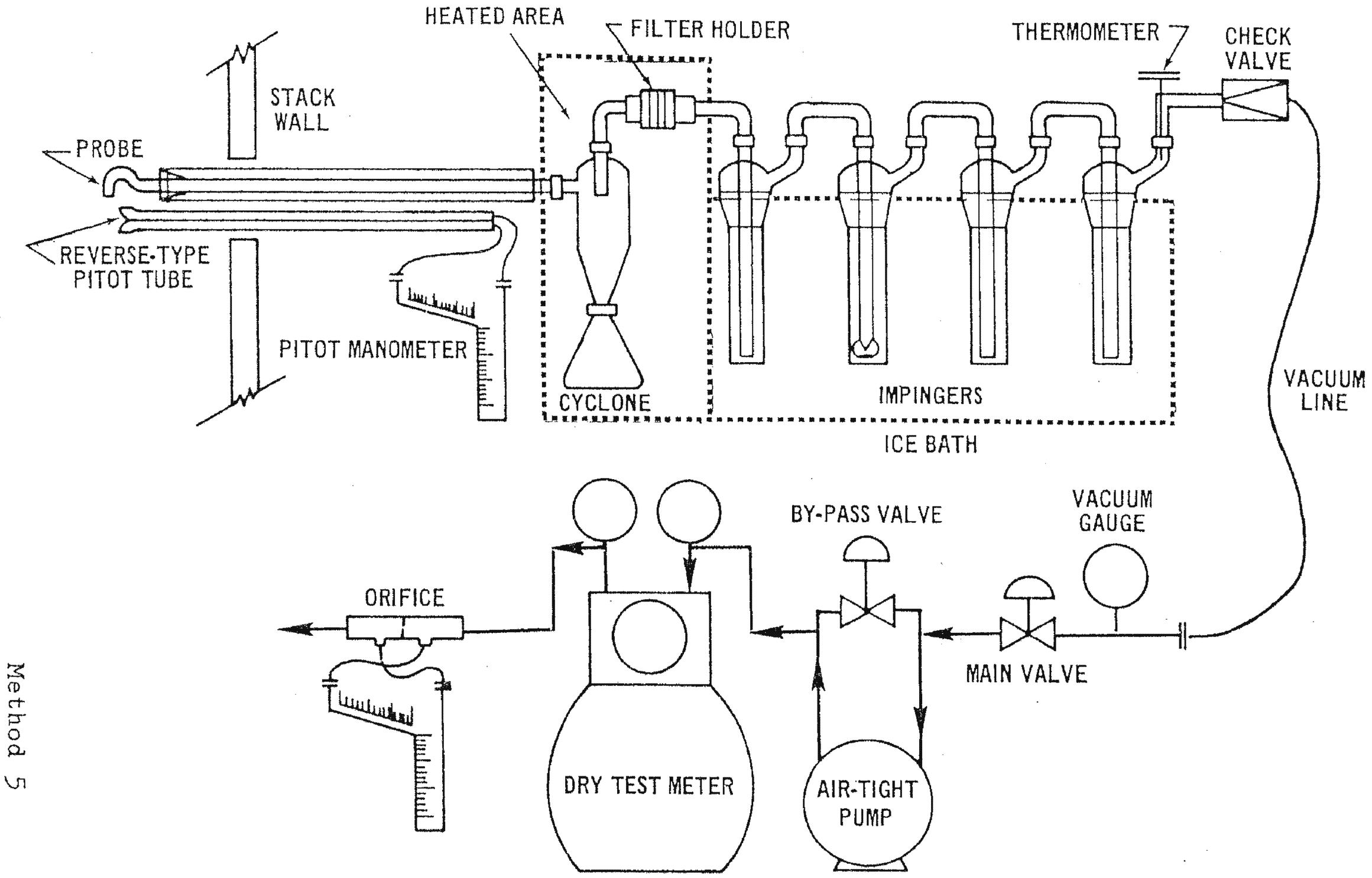
The initial gas stream velocity was obtained from a preliminary traverse using an "S" type pitot tube. The initial moisture was estimated from previous tests of similar processes. This data, along with the stack temperature, was used to set a nomograph so that rapid calculations of isokinetic sampling conditions could be made.

The principle of the method was to collect the sample representative of the exhaust by adjusting the sample collection velocity to match the exhaust gas stream velocity at the point of collection. The velocity at the point of collection was measured with an "S" type pitot tube attached to the probe and the collection velocity was matched to the stack gas velocity by adjusting the flow as indicated by the calibrated orifice.

To determine the molecular weight of the stack gas, samples were drawn into an Orsat analyzer and analyzed for percentage CO2, O2, CO, and N2.

At the completion of the test, the probe and tip preceding the filter was washed (rinsed, brushed, and rinsed three times) with acetone. This rinse was later placed in a tared beaker along with a rinse of the filter-holding glassware and evaporated to dryness at room temperature. The filter and beakers were then desiccated to the tared humidity conditions and weighed. These combined weights constituted the filterable (or "front-half") particulate catch.

The impinger contents were measured and weighed for determination of the actual moisture content of the exhaust gas stream. Blanks of the sample solutions were also analyzed in similar fashion to the field samples. All test results were blank subtracted as appropriate.




Particulate sampling train.

## 4.0 CALIBRATION DATA

The probe tip, pitot tube, dry gas meter, and sample box orifice used in the isokinetic test efforts were calibrated prior to the testing in accordance with the procedures outlined in the Maintenance, Calibration, and Operation of Isokinetic Source-Sampling Equipment as published by the US EPA. The values obtained were:

| Stack - Test Parameter | Date | Control Box ID | Orifice Coeff. ($\Delta H@$) | Dry Gas Meter Coeff. ($\gamma$) | Probe Tip Diameter |
|---|---|---|---|---|---|
| | | | | | |
| S08 - Particulate | 5/27 | 3 | 0.999 | 0.997 | 0.500 in. |
| | | | | | |

The flow measurements were made with an S-type pitot tube attached to the sampling probe. For the sampling probe used, the "S-type" Pitot tube coefficient ($C_p$) was 0.84. Prior to beginning the testing, the null angles were measured to verify the absence of cyclonic flow. All of the null angles were 15 degrees or less and averaged less than 5 degrees; this validated the flow measurements and sampling location since these figures were less than the acceptable 20 percent criteria.

The dry gas meter installed in the control box was a temperature compensating meter. The correction factor (gamma) for the meter could best be described by the following equation:

**Box 3 -** $\gamma = 0.997 + [(T_M - 70) \times 0.00012]$

The most recent calibrations on the particulate sampling equipment with regard to these test efforts were performed on April 22, 2020.

The isokinetic ratios for the test runs ranged from 94.7 to 96.1 percent, within the acceptable range of 90 to 110 percent.

# APPENDIX A

## Production Related Data

## *GBMSD Stack Testing Results*

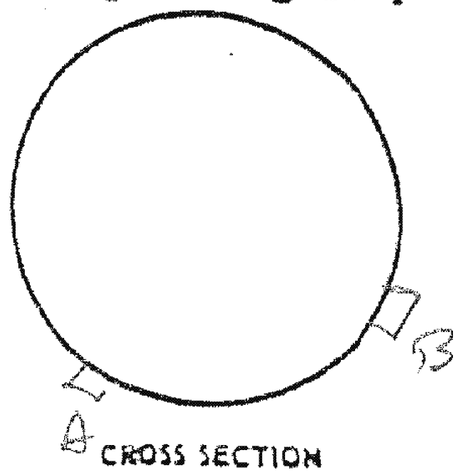
**Green Bay Facility - Fluid Bed Incinerator**
**FBI Feed**
**5/27/2020**

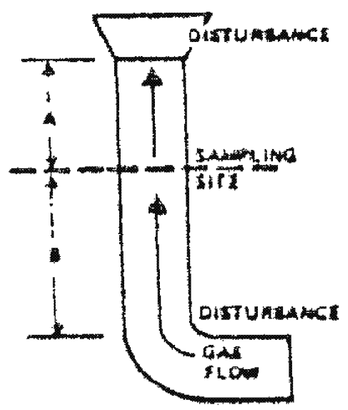
| DATE | Run | LAB NO. | SAMPLE | %TS | %VS | Wet gal/hr | Wet lbs/hr | Dry lbs/hr | Dry ton/hr |
|---|---|---|---|---|---|---|---|---|---|
| 5/27/2020 | Run #1 | 200701-01 | TEST 1 | 38.3 | 69.3 | 1010 | 10241.4 | 3922 | 1.961 |
| | | | | | | | | | |
| 5/27/2020 | Run #2 | 200701-02 | TEST 2 | 39.5 | 69.2 | 1012 | 10261.7 | 4053 | 2.027 |
| | | | | | | | | | |
| 5/27/2020 | Run #3 | 200701-03 | TEST 3 | 39.7 | 69.1 | 986 | 9998.04 | 3969 | 1.985 |

# APPENDIX B

## Field and Lab Data Sheets

Environmental
Technology &
Engineering Corp.




# PARTICULATE FIELD DATA

PLANT GBMSD
DATE 5/27/20
LOCATION GREEN BAY, WI
OPERATOR MJH/CSJ
STACK NO. I08 FINAL
RUN NO. 1
SAMPLE BOX NO. 1
METER BOX NO. 3

AMBIENT TEMPERATURE 75
BAROMETRIC PRESSURE 29.28
ASSUMED MOISTURE, % 1½%
PROBE LENGTH, in. 3ft
NOZZLE DIAMETER, in. 1/4"
STACK DIAMETER, in. 24
PROBE HEATER SETTING 250
HEATER BOX SETTING 250

METER ΔH@ .999 (δ = .997) 4/22
C FACTOR Cp = .84

PROCESS WEIGHT RATE

ORSAT RESULTS (BAG 53)
CO2 8.3%
O2 9.8%
CO 0
N2 BAL

LEAK CHECKS
Pre <.01@20"
Pitot OK@3"
Post <.01@20"
Pitot OK@3"

FNT 287

5 min/PT

| TRAVERSE POINT NUMBER | SAMPLING TIME (θ), min. | STATIC PRESSURE (in. $H_2O$) | STACK TEMPERATURE ($T_s$), °F | VELOCITY HEAD ($\Delta P_s$) CYCLONIC NOLS ($\sqrt{\Delta P_s}$) | | PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH) in. $H_2O$ ACTUAL | DESIRED | GAS SAMPLE VOLUME (Vm), ft³ | GAS SAMPLE TEMPERATURE AT DRY GAS METER: INLET ($Tm_{IN}$), °F | OUTLET ($Tm_{OUT}$), F | SAMPLE BOX TEMPERATURE °F | TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER F | PUMP VACUUM in. Hg gauge | CPM FILTER TEMP VELOCITY fps |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 8:50 | | 123 | .81 | 0° | 1.70 | | 4622.00 | | 81 | 240 | <50 | 2 | 77 |
| 2 | 55 | -.60 | 124 | .85 | 0 | 1.79 | | 26.7 | | 82 | | | | 78 |
| 3 | 9:00 | | 124 | .82 | 0 | 1.72 | | 31.4 | | 84 | 255 | <50 | 2 | 78 |
| 4 | :05 | | 122 | .75 | 5 | 1.58 | | 36.1 | | 88 | | | | 79 |
| 5 | :10 | -.61 | 121 | .92 | 15 | 1.93 | | 40.6 | | 91 | 250 | <50 | 2+ | 79 |
| 6 | :15 | | 121 | .87 | 10 | 1.83 | | 45.5 | | 95 | | | | 80 |
| B1 | 20/22 | | 121 | .60 | 10° | 1.26 | | 50.2 | | 99 | 250 | <50 | <2 | 80 |
| 2 | 27 | -.45 | 121 | .76 | 5 | 1.60 | | 54.3 | | 103 | | | | 79 |
| 3 | 32 | | 122 | .84 | 0 | 1.76 | | 58.7 | | 108 | 255 | <50 | 2 | 80 |
| 4 | 37 | | 121 | .93 | 0 | 1.95 | | 63.4 | | 111 | | | | 80 |
| 5 | 42 | -.49 | 121 | .97 | 0 | 2.04 | | 68.2 | | 114 | 245 | <50 | 2+ | 81 |
| 6 | 47 | | 120 | .87 | 5 | 1.83 | | 73.2 | | 118 | | | | 82 |
| | 9:52 | | | | | | | 4677.83 | | | | | | |
| | | | | | | | | 55.83 | | | | | | |

# LABORATORY DATA SHEET
# PARTICULATE & WATER COLLECTED

JOB NAME GBMSD DATE OF TEST 5-27-2020

JOB NO. _____ TEST ENGINEER MJH

RUN NO. 1 STACK S08

Sample Box 1 Filter 283 Wash Bottle —

Beaker No. 1

## WATER COLLECTED

| Impinger No. | Final Wt. g | Initial Wt. g | Collected grams |
|---|---|---|---|
| 1 | 112 | 100 | 12 |
| 2 | 104 | 100 | 4 |
| 3 | 2 | 0 | 2 |
| SILGEL | 665 | 654 | 11 |
| | | TOTAL | 29 |

## PARTICULATE COLLECTED

| | | Final Wt. g | Tare Wt. g | Collected grams |
|---|---|---|---|---|
| Filter | .0002 | .3496 | .3489 | .0005 |
| Washings | —.0001 | 102.1699 | 102.1655 | .0045 |
| | | | TOTAL | .0050 |

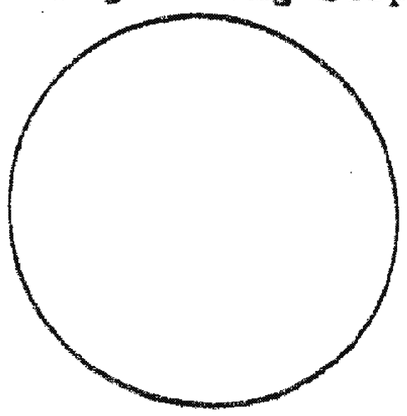
WATER COLLECTED [ ] GRAMS

PARTICULATE COLLECTED [ ] GRAMS

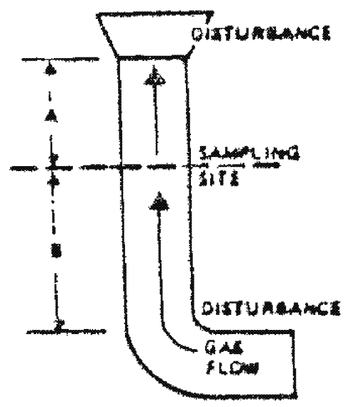
NOTES:

Environmental
Technology &
Engineering Corp.

# PARTICULATE FIELD DATA



CROSS SECTION




PLANT GBNSD
DATE 5/27/20
LOCATION GREEN BAY, WI
OPERATOR MJN/CSN
STACK NO. I08
RUN NO. 2
SAMPLE BOX NO. 2
METER BOX NO. 3

AMBIENT TEMPERATURE 78
BAROMETRIC PRESSURE 29.27
ASSUMED MOISTURE, % 1½%
PROBE LENGTH, in. 3 FT
NOZZLE DIAMETER, in. ¼"
STACK DIAMETER, in. 24
PROBE HEATER SETTING 250
HEATER BOX SETTING 250

METER ΔH@ .999 (γ: .997) 4/22
C FACTOR Cp = .84
PROCESS WEIGHT RATE

ORSAT RESULTS (BAG 61)
CO2 8.2%
O2 9.8
CO 0
N2 BALANCE

LEAK CHECKS
Pre <.01 @ 20" OK
Pitot OK @ 3" OK
Post <.01 @ 20" OK
Pitot OK @ 3" OK

FILT 288

5 min/pt

| TRAVERSE POINT NUMBER | SAMPLING TIME (Θ), min. | STATIC PRESSURE (in. $H_2O$) | STACK TEMPERATURE ($T_s$), °F | VELOCITY HEAD ($\Delta P_s$) | ($\sqrt{\Delta P_s}$) | PRESSURE DIFFERENTIAL ACROSS ORIFICE METER ($\Delta H$) in. $H_2O$ ACTUAL | DESIRED | GAS SAMPLE VOLUME (Vm), $ft^3$ | GAS SAMPLE TEMPERATURE AT DRY GAS METER: INLET ($Tm_{IN}$), °F | OUTLET ($Tm_{OUT}$), F | SAMPLE BOX TEMPERATURE °F | TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER F | PUMP VACUUM in. Hg gauge | CPM FILTER TEMP. VELOCITY $\sqrt{\Delta P_s}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A 1 | 10'06 | | 122 | .89 | | 1.87 | | 4679.00 | | 118 | 230 | <50 | 2 | 78 |
| 2 | :11 | -.46 | 122 | .86 | | 1.81 | | 83.7 | | 119 | | | | 78 |
| 3 | :16 | | 122 | .79 | | 1.66 | | 88.5 | | 120 | 250 | <50 | 2 | 79 |
| 4 | :21 | | 123 | .70 | | 1.47 | | 93.9 | | 121 | | | | 79 |
| 5 | :26 | -.44 | 122 | .78 | | 1.64 | | 97.1 | | 122 | 260 | <50 | 2 | 79 |
| 6 | :31 | | 122 | .98 | | 2.06 | | 4701.6 | | 124 | | | | 80 |
| B 1 | 36/:38 | | 122 | .77 | | 1.62 | | 706.4 | | 127 | 255 | <50 | 2 | 80 |
| 2 | :43 | -.51 | 123 | .80 | | 1.68 | | 10.9 | | 128 | | | | 80 |
| 3 | :48 | | 123 | .82 | | 1.72 | | 15.4 | | 129 | 255 | <50 | 2 | 81 |
| 4 | :53 | | 122 | .97 | | 2.04 | | 19.8 | | 130 | | | | 81 |
| 5 | :58 | -.54 | 123 | .91 | | 1.91 | | 24.7 | | 131 | 250 | <50 | 2+ | 83 |
| 6 | 11:03 | | 123 | .73 | | 1.53 | | 29.4 | | 133 | | | | 84 |
| | 11:08 | | | | | | | 4733.75 | | | | | | |
| | | | | | | | | 54.75 | | | | | | |

# LABORATORY DATA SHEET
# PARTICULATE & WATER COLLECTED

JOB NAME GBMSD DATE OF TEST 5-27-2020

JOB NO. _____ TEST ENGINEER MJH

RUN NO. 2 STACK 508

Sample Box 2 Filter 289 Wash Bottle —

Beaker No. 2

## WATER COLLECTED

| Impinger No. | Final Wt. g | Initial Wt. g | Collected grams |
|---|---|---|---|
| 1 | 111 | 100 | 11 |
| 2 | 109 | 100 | 9 |
| 3 | 4 | 0 | 4 |
| SILICA | 678 | 670 | 8 |
| | | TOTAL | 32 |

## PARTICULATE COLLECTED

| | | Final Wt. g | Tare Wt. g | Collected grams |
|---|---|---|---|---|
| Filter | .0002 | .3499 | .3492 | .0005 |
| Washings | -.0001 | 102.5429 | 102.5380 | .0050 |
| | | | TOTAL | .0055 |

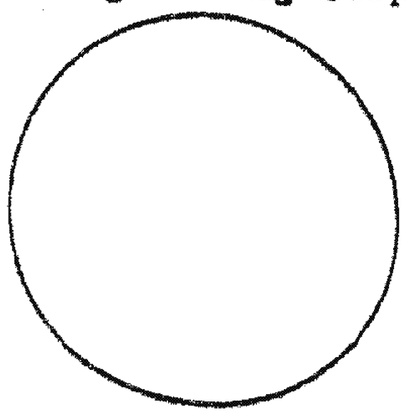
WATER COLLECTED [ ] GRAMS

PARTICULATE COLLECTED [ ] GRAMS

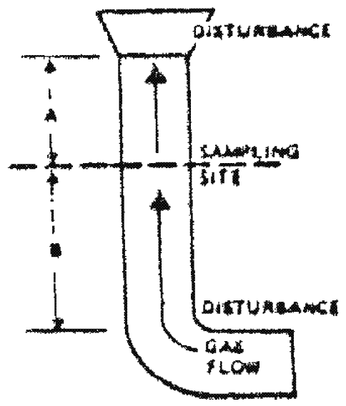
NOTES:

Environmental
Technology &
Engineering Corp.

# PARTICULATE FIELD DATA



CROSS SECTION




PLANT GBNSD
DATE 5/27/2020
LOCATION GREEN BAY, WI
OPERATOR MW/CSH
STACK NO. 108 STACK
RUN NO. 3
SAMPLE BOX NO. 3
METER BOX NO. 3

AMBIENT TEMPERATURE 77 F
BAROMETRIC PRESSURE 29.26
ASSUMED MOISTURE, % 1½%
PROBE LENGTH, in. 3 FT
NOZZLE DIAMETER, in. ¼"
STACK DIAMETER, in. 24"
PROBE HEATER SETTING 250 F
HEATER BOX SETTING 250

METER ΔH@ γ=.999 .999 4/22
C FACTOR Cp=.84

PROCESS WEIGHT RATE

ORSAT RESULTS

| | | |
|---|---|---|
| CO2 | 7.9% | BAL |
| O2 | 10.3 | |
| CO | 0 | |
| N2 | BAL | |

LEAK CHECKS

Pre <.01@20"
Pitot OK@3"
Post <.01@20"
Pitot OK@3"

FILT 289

5 min/pt

| TRAVERSE POINT NUMBER | SAMPLING TIME (θ), min. | STATIC PRESSURE (in. $H_2O$) | STACK TEMPERATURE ($T_s$), °F | VELOCITY HEAD ($\Delta P_s$) ($\sqrt{\Delta P_s}$) | PRESSURE DIFFERENTIAL ACROSS ORIFICE METER ($\Delta H$) in. $H_2O$ ACTUAL | DESIRED | GAS SAMPLE VOLUME (Vm), ft³ | GAS SAMPLE TEMPERATURE AT DRY GAS METER INLET ($Tm_{IN}$), °F | OUTLET ($Tm_{OUT}$), F | SAMPLE BOX TEMPERATURE °F | TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER F | PUMP VACUUM in. Hg gauge | OPM FILTER TEMP VELOCITY fps |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A1 | 11:20 | | 123 | .83 | 1.74 | | 4735.00 | | 130 | 235 | <50 | 2 | 78 |
| 2 | 25 | -.55 | 123 | .77 | 1.62 | | 39.6 | | 129 | | | | 78 |
| 3 | 30 | | 122 | .72 | 1.51 | | 44.0 | | 130 | 250 | <50 | <2 | 78 |
| 4 | 35 | | 122 | .86 | 1.81 | | 48.3 | | 131 | | | | 79 |
| 5 | 40 | -.58 | 122 | .99 | 2.08 | | 52.9 | | 132 | 255 | <50 | 2+ | 81 |
| 6 | 45 | | 122 | .92 | 1.93 | | 57.8 | | 132 | | | | 82 |
| B1 | 50/52 | | 122 | .65 | 1.37 | | 62.6 | | 133 | 245 | <50 | <2 | 83 |
| 2 | 57 | -.50 | 122 | .74 | 1.55 | | 66.7 | | 134 | | | | 81 |
| 3 | 12:02 | | 122 | .84 | 1.76 | | 71.0 | | 136 | 260 | <50 | 2 | 81 |
| 4 | 07 | | 123 | .93 | 1.95 | | 75.3 | | 137 | | | | 82 |
| 5 | 12 | -.53 | 122 | .97 | 2.04 | | 80.2 | | 138 | 255 | <50 | 2½ | 83 |
| 6 | 17 | | 123 | .79 | 1.66 | | 85.0 | | 139 | | | | 84 |
| | 12:22 | | | | | | 4789.64 | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | 54.64 | | | | | | |
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# LABORATORY DATA SHEET
# PARTICULATE & WATER COLLECTED

JOB NAME GBMSD DATE OF TEST 5-27-2020

JOB NO. _____ TEST ENGINEER MJH

RUN NO. 3 STACK SO8

Sample Box 3 Filter 291 Wash Bottle —

Beaker No. 3

## WATER COLLECTED

| Impinger No. | Final Wt. g | Initial Wt. g | Collected grams |
|---|---|---|---|
| 1 | 114 | 100 | 14 |
| 2 | 110 | 100 | 10 |
| 3 | 3 | 0 | 3 |
| SILGEL | 700 | 692 | 8 |
| | | TOTAL | 35 |

## PARTICULATE COLLECTED

| | | Final Wt. g | Tare Wt. g | Collected grams |
|---|---|---|---|---|
| Filter | .0002 | .3531 | .3523 | .0006 |
| Washings | -.0001 | 103.1771 | 103.1735 | .0037 |
| | | | TOTAL | .0043 |

WATER COLLECTED [ ] GRAMS

PARTICULATE COLLECTED [ ] GRAMS

NOTES:

# APPENDIX C

## Detailed Equations of PM Calculations

# SAMPLE PARTICULATE CALCULATION SHEET

| | | |
|---|---|---|
| TEST NO. | Sample | |
| BAROMETRIC PRESSURE (Pb) | 29.45 | IN HG |
| TIP DIAMETER (d) | 0.305 | IN |
| STACK DIAMETER (D) | 72 | IN |
| STACK AREA (As=PI*D^2/576) | 28.274 | FT2 |
| SAMPLING TIME PER POINT | 2.5 | MIN |
| NUMBER OF POINTS | 24 | |
| METER VOLUME (Vm) | 66.53 | FT3 |
| PITOT COEFFICIENT (cp) | 0.84 | |
| METER COEFFICIENT (GAMA) | 0.990 | |
| PARTICULATE COLLECTED (Mn) | 0.0500 | GRAMS |
| WATER COLLECTED (Vf-Vi) | 32 | ML |
| STATIC PRESSURE (Ps) | -0.5 | IN H2O |

ORSAT RESULTS

| CO2 | O2 | CO | N2 |
|---|---|---|---|
| 6.40% | 13.40% | 0.00% | 80.20% |

| POINT | STACK TEMP DEG F | DELTA P IN H2O | ORIFICE DEL P IN H2O | METER TEMP DEG F | VELOCITY AFPS |
|---|---|---|---|---|---|
| 1 | 275 | 0.32 | 2.20 | 35 | 37.52 |
| 2 | 280 | 0.37 | 2.55 | 38 | 40.48 |
| 3 | 278 | 0.37 | 2.55 | 40 | 40.42 |
| 4 | 278 | 0.40 | 2.80 | 41 | 42.03 |
| 5 | 280 | 0.50 | 3.50 | 43 | 47.05 |
| 6 | 281 | 0.70 | 4.90 | 44 | 55.71 |
| 7 | 282 | 0.72 | 5.00 | 44 | 56.54 |
| 8 | 280 | 0.72 | 5.00 | 44 | 56.46 |
| 9 | 280 | 0.62 | 4.30 | 45 | 52.40 |
| 10 | 277 | 0.57 | 3.90 | 46 | 50.14 |
| 11 | 276 | 0.65 | 4.50 | 47 | 53.50 |
| 12 | 275 | 0.60 | 4.20 | 48 | 51.37 |
| 13 | 282 | 0.70 | 4.90 | 50 | 55.75 |
| 14 | 283 | 0.82 | 5.70 | 53 | 60.38 |
| 15 | 282 | 0.85 | 6.00 | 56 | 61.43 |
| 16 | 283 | 0.75 | 5.20 | 60 | 57.74 |
| 17 | 280 | 0.59 | 4.10 | 62 | 51.11 |
| 18 | 280 | 0.60 | 4.20 | 65 | 51.54 |
| 19 | 280 | 0.60 | 4.20 | 67 | 51.54 |
| 20 | 278 | 0.65 | 4.50 | 70 | 53.58 |
| 21 | 279 | 0.72 | 5.00 | 72 | 56.43 |
| 22 | 280 | 0.72 | 5.00 | 74 | 56.46 |
| 23 | 277 | 0.65 | 4.50 | 75 | 53.54 |
| 24 | 275 | 0.30 | 2.10 | 75 | 36.32 |
| AVERAGE | 279 (Tsavg) | | 4.20 (DELH) | 54 (Tm) | 51.23 (vsavg) |

| | | |
|---|---|---|
| DRY STANDARD VOLUME (Vmstd) | 65.51 | SCF |
| PERCENT WATER VAPOR %H2O) | 2.25 | % VOL |
| FLOW RATE (Q) | 86905 | ACFM |
| | 59651 | DSCFM |
| | 101360 | M3/HR |
| PARTICULATE CONCENTRATION (cs) | 0.0118 | GR/DSCF |
| PARTICULATE EMISSION RATE (ER) | 6.08 | LB/HR |
| LB PART PER 1000 LB GAS (EC) | 0.0219 | |
| ISOKINETIC PERCENT (I) | 102.0 | |

# PARTICULATE SAMPLE CALCULATION FORMULA

**1. DRY MOLECULAR WEIGHT (Md)** lb/lb-mole

Md = .44*% CO2 + .32*%O2 + .28*%N2 + .28*%CO

**2. WATER VAPOR PERCENT (%H2O)**

Vw std = 0.04707*(Vf - Vi)

where: Vw std = standard cubic feet of water vapor
Vf = Final volume of impingers, ml
Vi = Initial volume of impingers, ml

%H2O = Vw std * 100/(Vm std + Vw std)

where Vm std = standard cubic feet of gas sampled

**3. WET MOLECULAR WEIGHT (Ms)** lb/lb-mole

Ms = Md*(1 - %H2O/100) + 18*%H2O/100

**4. STACK PRESSURE (Ps)** in. Hg.

Ps = Pb + Pg/13.6

where: Pb = barometric pressure (uncorrected), in. Hg
Pg = stack gauge pressure, in. H2O
13.6 = specific gravity of mercury (Hg)

**5. AVERAGE STACK VELOCITY (vs)** feet per second

Vs = Kp*Cp*DELP * (Tsavg/(Ps*Ms))^0.5

where: Kp = 85.49 unit conversion
Cp = 0.84, pitot tube calibration factor
DELP = average of square root of velocity head, in. H2O
Tsavg = average stack temperature, deg R (460+F)
Ps = stack pressure
Ms = wet molecular weight

6. **STACK GAS FLOW RATE (Qs)** std. cubic feet per minute

Qs = 60*(1 - %H2O/100)*Vs*A*(528*Ps/Tsavg/29.92)

where: A = stack area, ft2
528 = std temperature, deg R
29.92 = std pressure, in. Hg

7. **DRY GAS VOLUME (Vmstd)** dry std. cubic feet

Vm std = (GAMAC*(Pb+ DELH/13.6)/29.92) * Vm

where: GAMAC = dry gas meter calibration factor corrected for meter temperature (GAMA+(Tm-70)*.00012)
Vm = volume of dry gas metered, cubic feet
Tm = average meter temperature, degrees F
DELH = average orifice pressure drop, in.H2O

8. **PARTICULATE CONCENTRATION (cs)** grains per dry standard cubic foot

Cs = Mn * 15.43/Vm std
where: Mn = particulate captured, grams
15.43 = grains per gram

9. **EMISSION RATE (ER)** pounds per hour

PMRA = Mn*A*60/(t*An*453.6) AREA METHOD lb/hr

PMRC = Cs*Qs*60/(15.43*453.6) CONC. METHOD lb/hr

ER = (PMRA + PMRC)/2

where: An = area of sampling nozzle, square feet

10. **EMISSION CONCENTRATION (EC)** lb/1000 lb exhaust gas

EC = ER * 386700 * (1-%H2O/100)/(Qs*60*Ms)

where: 386700 = cubic feet per lb mole * 1000

11. **ISOKINETIC SAMPLING PERCENTAGE (I)**

I = PMRA/PMRC